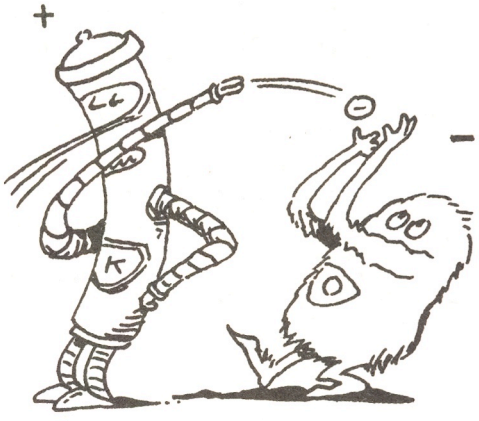
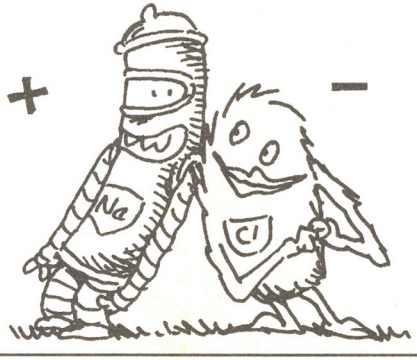
Ionic Bonds

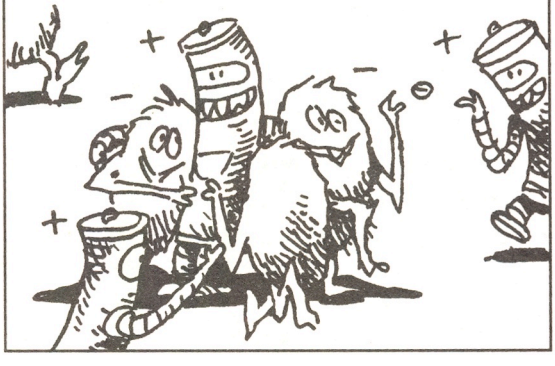
WHEN A HIGHLY ELECTROPOSITIVE ATOM MEETS A HIGHLY ELECTRONEGATIVE ONE, THE RESULT IS AN IONIC BOND. THE ELECTROPOSITIVE ATOM EASILY GIVES AWAY ONE OR MORE ELECTRONS AND BECOMES A POSITIVELY CHARGED CATION. THE ELECTRONEGATIVE ATOM LOVES TO ACQUIRE EXTRA ELECTRONS AND IN DOING SO BECOMES AN ANION.



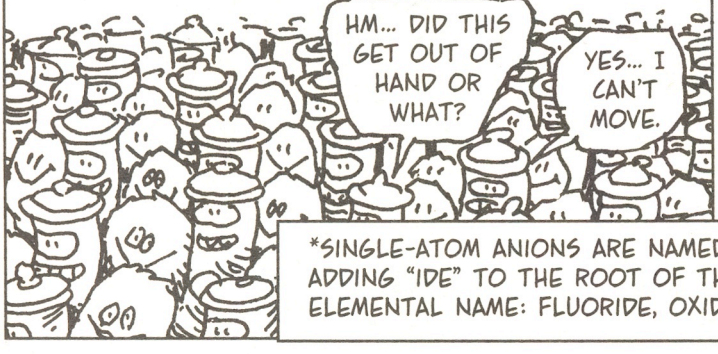
THE TWO IONS THEN EXPERIENCE AN ELECTROSTATIC ATTRACTION.



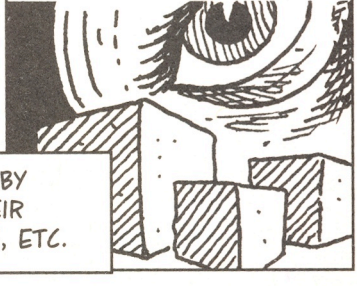
IN FACT, THEY ATTRACT NOT ONLY EACH OTHER, BUT EVERY OTHER CHARGED PARTICLE IN THE NEIGHBORHOOD.



THEIR MUTUAL ATTRACTION PACKS THEM TOGETHER IN A DENSE, REGULAR **IONIC CRYSTAL.** IN THE CASE OF SODIUM AND CHLORIDE,* EACH ION HAS A SINGLE CHARGE SO NEUTRALITY IS ACHIEVED BY THIS SIMPLE CUBIC ARRANGEMENT:

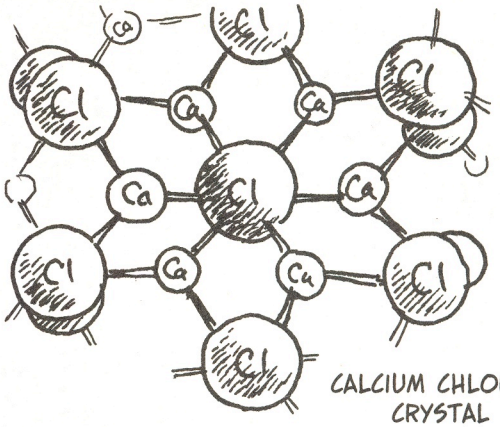


IF YOU LOOK CLOSELY AT TABLE SALT, YOU CAN SEE THAT THE CRYSTALS ARE LITTLE CUBES—EACH ONE A MONSTER ARRAY OF SODIUM AND CHLORIDE IONS.



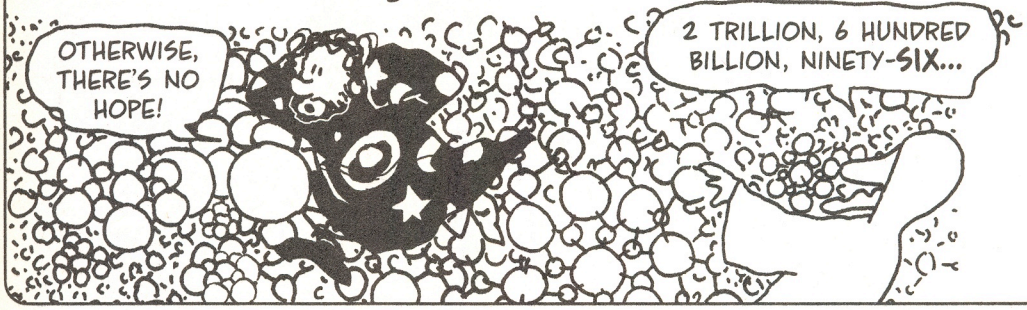
*SINGLE-ATOM ANIONS ARE NAMED BY ADDING "IDE" TO THE ROOT OF THEIR ELEMENTAL NAME: FLUORIDE, OXIDE, ETC.

OTHER IONS MAY FORM DIFFERENT CRYSTALLINE STRUCTURES. WHEN CALCIUM, WHICH GIVES UP TWO ELECTRONS, COMBINES WITH CHLORINE, WHICH ACCEPTS ONLY ONE, TWO CHLORIDE IONS ARE NEEDED TO NEUTRALIZE EACH CALCIUM. WE WRITE AN ION WITH ITS ELEMENT SYMBOL AND CHARGE. SO THE CALCIUM ION IS Ca^{2+}, AND CHLORIDE IS Cl^-.

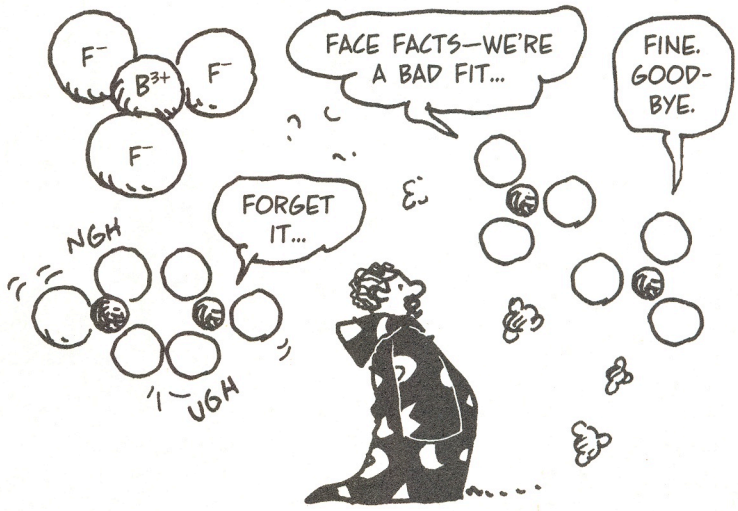


CALCIUM CHLORIDE CRYSTAL

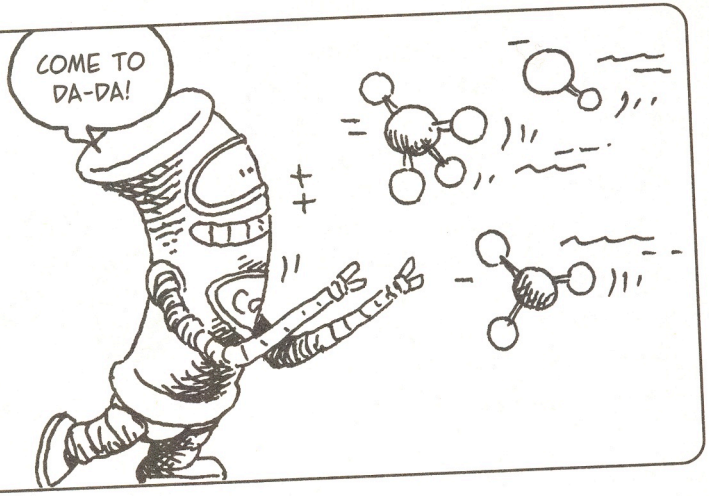
THE FORMULA OF THESE IONIC CRYSTALS IS GIVEN "IN LOWEST TERMS." EVEN THOUGH A SODIUM CHLORIDE CRYSTAL MAY CONTAIN TRILLIONS OF ATOMS, WE WRITE ITS **EMPIRICAL FORMULA** AS NaCl. THIS SHOWS THAT THE CRYSTAL HAS ONE SODIUM ION FOR EACH CHLORIDE. IN THE SAME WAY, CALCIUM CHLORIDE IS WRITTEN $CaCl_2$.



OCCASIONALLY, IONICALLY BONDED ATOMS HAVE NO NATURAL CRYSTALLINE ARRANGEMENT. INSTEAD THEY CLUMP TOGETHER INTO SMALL GROUPS CALLED **MOLECULES.** BORON TRIFLUORIDE, BF_3, IS AN IONIC COMPOUND THAT IS GASEOUS AT ROOM TEMPERATURE.



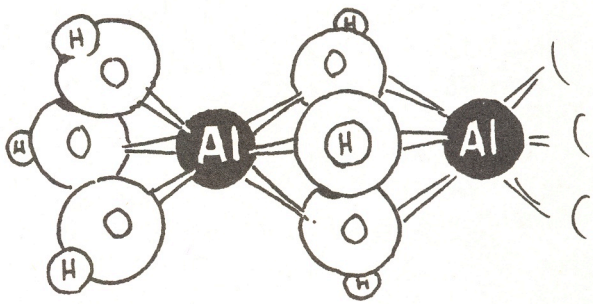
SOME IONS CONSIST OF MORE THAN ONE ATOM. WE'LL SEE HOW TO BUILD THESE **POLYATOMIC** IONS LATER IN THE CHAPTER. THESE THINGS BEHAVE VERY MUCH LIKE MONOATOMIC IONS, EXCEPT FOR THEIR SHAPE. THE WHOLE STRUCTURE ACTS AS A SINGLE CHARGED UNIT.



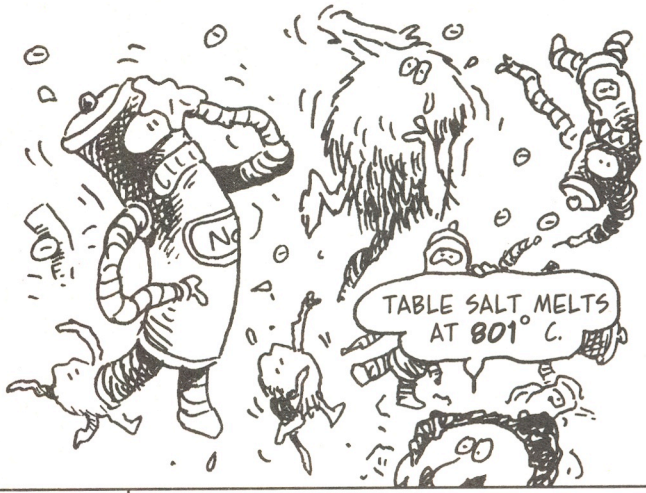
A TYPICAL EXAMPLE IS **SULFATE,** SO_4^{2-}, AN ANION THAT BONDS WITH Ca^{2+} TO MAKE **CALCIUM SULFATE,** $CaSO_4$, AN INGREDIENT OF WALLBOARD.

NH_4^+	AMMONIUM
OH^-	HYDROXIDE
NO_2^-	NITRITE
NO_3^-	NITRATE
HCO_3^-	BICARBONATE
CO_3^{2-}	CARBONATE
SO_3^{2-}	SULFITE
PO_4^{3-}	PHOSPHATE

EACH POLYATOMIC ION MUST BE REGARDED AS A SINGLE ION. FOR EXAMPLE, ALUMINUM HYDROXIDE, WHICH COMBINES Al^{3+} AND OH^-, MUST HAVE THREE HYDROXIDES TO BALANCE EACH ALUMINUM. THE FORMULA IS WRITTEN $Al(OH)_3$, AND THE CRYSTAL STRUCTURE LOOKS LIKE THIS:

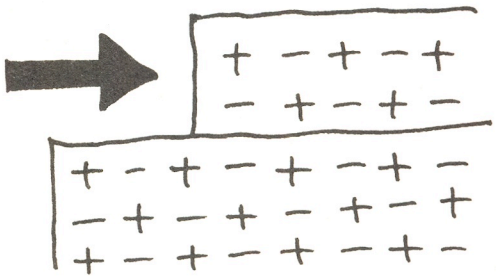


IONIC BONDS ARE STRONG. IT TAKES A LOT OF ENERGY TO BREAK THEM. THIS EXPLAINS WHY MOST IONIC CRYSTALS HAVE SUCH HIGH MELTING POINTS: TREMENDOUS HEAT IS NEEDED TO JAR THE IONS LOOSE AND GET THEM SLOSHING AROUND AS A LIQUID.



AND YET—HIT A SALT CRYSTAL WITH A HAMMER AND IT CRUMBLES. WHY SHOULD IT BE SO BRITTLE?

ANSWER: WHEN WHACKED, THE CRYSTAL MAY DEVELOP TINY CRACKS, AND ONE LAYER MAY SHIFT SLIGHTLY ACROSS ANOTHER.



THIS SHIFT CAN ALIGN POSITIVES OPPOSITE POSITIVES AND NEGATIVES OPPOSITE NEGATIVES. NOW THE TWO CHUNKS REPEL EACH OTHER, AND THE CRYSTAL LITERALLY FLIES APART.

BUT NOT ALL CRYSTALS BEHAVE THIS WAY—METALLIC CRYSTALS, FOR EXAMPLE...